VARIATIONS OF SOIL TEMPERATURE IN SANDY SOIL AND THEIR RELATIONS TO ALFALFA PLANTS

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ABSTRACT:

To study the variations of soil temperature in sandy soil and their relations to Alfalfa plant growth, eight thermal sensors were placed in two sites at different depths in a sandy soil at Ismailia Agricultural Research Station, and cultivated with alfalfa crop (*Medicago sative*) under sprinkler irrigation. After the plantation of alfalfa seeds, four plots were chosen for soil temperature (A, B, C, and D); each one represented one meter square plot. Two sites; one between A and B and the other between C and D plots were chosen to put the temperature sensors at four depths of; 0.05, 0.10, 0.15 and 0.30 m. At the end of the experiment, the average of the two sites was calculated for each depth. The alfalfa plants were cut every 28 days for each plot (seven days apart in dual way between the four plots) from January till October, where they equal 40 cuts/10 months.

The results revealed that soil temperature decreased at the day night until the seventh to eightieth O'clock a.m., after sunrise it increased at the day light until the third to fifth O'clock p.m. at the surface layers depth for the previous months, while the values of the studied deepest layer (0.3m) decreased at day night until the ninth to tenth O'clock a.m., and after sunrise, it increased until the sixth to eighth O'clock p.m. after sunset.

The minimum soil temperatures were 6, 6.64, 6.07 and 9.33ºC in February and the maximum were 35.58, 34.83, 38.15 and 31.79°C in July for the aforementioned depths, respectively.

Alfalfa dry weight (kg/m^2) was positively significant correlated with the average soil temperature through the period of cuts. The minimum dry weight values (1.67 kg/m^2) was at the 2nd cut at the temperature average (13.20°C), while the maximum values of dry weight (6.70 kg/m^2) was at the 23rd cut at soil temperature average (26.20°C).

The available K, Mn and Zn showed no significant correlation with soil temperature, while the available Fe was highly significant correlated with soil temperature. There were negative significant correlations between plant NPK concentrations and soil temperature, and this related to dilution with increase plant growth, whereas the uptake of P and K showed positive and significant correlation with soil temperature.

Key words: alfalfa crop, sandy soil, soil temperature.

INTRODUCTION:

Soil temperature is a factor of primary importance in determining the rates and directions of soil physical properties and strongly influences its biological processes, such as seed germination, seedling emergence and growth, root development and microbial activity **(Hillel, 2004)**. A change in soil temperature, caused by a gain or a loss of heat from the soil, depends on the specific heat and the heat capacity of the soil. The range of soil temperature change for a given heat gain or loss is governed by the heat capacity (**McInnes, 2002)**.

Soil temperatures vary within a few 10s of cm and the latter at greater depths. The transfer of heat in the soil at different thermal properties, coupled with radiations and latent heat exchanges at the surface are the primary cause of variations in soil temperature, (**Hu and Feng, 2002).** Soil surface temperature also represents an important boundary condition for modeling the soil thermal regime or the surface energy balance **(Horton et al., 1984 and Kluitenberg and Horton, 1990)**.

The temperature distribution in three zones are distinguished; (1).**Surface zone** reaching a depth of about 1m, in which the temperature is very sensitive to short time changes of weather conditions, (2).**Shallow zone** extending from the depth of about 1-8m (for dry light soils) or 20m (for moist heavy sandy soils) where the temperature is almost constant and close to the average annual air temperature. In this zone the temperature distribution depends mainly on the seasonal cycle weather conditions, (3).**Deep zone** (below 8-20m), where the temperature is practically constant and very slowly rising with depth according to the geothermal gradient, **(Popiel et al., 2001)**

Talaat and Said (2008) mentioned that actual soil temperature of the studied soil depths in the two measurement times decreased gradually with depth and increased from the early morning (at 7.00 am) to reach their maximum values at 3.00pm for the two upper soil layers (0-2.5 and 2.5-7.5cm) and 9.00pm and 12.00 (mid night) in the two bottom layers (7.5-15 and 15-20cm) respectively. After that soil temperature decreased gradually till 4.00 am (dawn). This indicates that the time lag periods required for occurring the maximum temperature in the two bottom layers were 6 and 9 hr, in the same sequence.

Concerning soil temperature and soil nutrients concentrations and plant uptake, climate change can affect soil nutrient availability and plant nutrient contents through affecting soil moisture, soil biological activity and plant growth. The increase of soil temperature can increase soil organic matter decomposition and mineralization rates **(Rustad et al., 2001 and Emmett et al., 2004)**. However, plant nutrient concentrations or accumulation will depend on whether plant growth also increases. The increased temperatures may enhance soil microbe activity, plant photosynthetic capacity and growth, thus enhancing nutrient capture and increasing their retention in the ecosystem.

Several investigations indicated that, soil temperature influence on nutrient uptake, metabolic processes and root and shoot growth (**Engels and Marschner 1992** and **McMichael and Burke 1998**). In many plant species, nutrient uptake by roots decreases at low root zone temperatures **(Toselli et al., 1999; Vasilieva et al., 1999, and Weih and Karlsson 1999)**.

Moreover, the soil temperature influences nitrogen volatilization in organic and inorganic compounds, such as N losses from surface-applied urea **(Fenn and Kissel, 1974 and Bouwmeester et al., 1985)**. Soil temperature and moisture are the primary determinants of growth rate for seedlings and root pathogens of many crops **(Hwang et al., 2000 a,b; Kraft and Roberts 1969 and Sippell and Hall 1982).**

The objective of this study is to through light on the variations of soil temperature in sandy soil through many depths under alfalfa plants and their relations to dry weight and plant nutrients.

MATERIALS AND METHODS:

To study the variations of soil temperature in sandy soil and their relations to Alfalfa plant growth, as well as soil and plant nutrients. Eight thermal sensors were placed in two sites at different depths in a sandy soil at Ismailia Agricultural Research Station. The soil was cultivated with alfalfa crop (*Medicago sative*) that planted in the first of November under sprinkler irrigation. Four square meter area was chosen and divided into four parts (A, B, C, and D), each one represented one square meter. Soil analyses are listed in Table (1).

Table (1): Particle size distributions and available nutrients of the experimental soil.

Fractions	0 – 20 cm	20 – 40 cm	Available nutrient (ppm)	0 – 20 cm	20 – 40 cm
Sand (%)	94.25	93.75	P	1.58	2.33
Silt (%)	4.35	4.43	K	43.35	42.86
Clay (%)	1.40	1.82	Zn	0.34	0.39
Texture class	Sandy	Sandy	Fe	4.59	4.35
			Mn	0.85	0.72
			Cu	0.87	0.98

One of the two sets of soil temperature thermocouple sensor was placed between A and B plots and the second between C and D plots. The sensors were placed at four depths as 0.05, 0.10, 0.15 and 0.30 m, from the soil surface. Data logger recorded the degree of soil temperature every 15 minuets which recorded (96 reading/day/sensor).

After the end of the experiment, data of the two sets were calculated the average temperature for each depth, to represent the four depths of four square meter. Variations of soil temperature were taken by regarding the recorded temperature from 1 to 302 DOY and every month with own days.

The first cut of alfalfa plants after plantation was at 1 DOY for plot A, at 8 DOY for plot B, at 15 DOY for plot C and at 22 DOY for plot D. These cuts were not taken into account of the experiment because they were regarded the plantation cuts and not subjected to symmetrical period for plant growth and on terms of parallel soil temperature readings.

Forty plant cuts and forty soil samples in the same time a day (10 a.m.) were collected from the overall experiment started from 29 DOY of plot A, then 36 DOY of B, 43 DOY of C, and 50 DOY of D, then repeat the cycle nine time (total ten cycle) as shown in Table (2). Soil temperature of 28 days versus every growth period were average of 2688 reading to every sensor, start from 1 to 302 DOY, they tabulated and depicted weekly (listed in Table 2).

Soil and plant samples were taken every cut from each plot according the trial period and subjected to analyses. Soil available nutrients were determined according to **Murphy and Riley, (1962), Jackson, (1967), and Soltanpour, (1985).** Dry weight and plant nutrients content were determined according to **Richards (1954)**. Statistical analyses had been done according to **Freed et al., (1989).**

A	**B**

D	C

Table (2): Alfalfa plant growth periods (days), time of plant cuts (DOY), soil sample and the soil temperature through the growth period of each plot (number of cuts are 40 cuts).

Plant Cut No.	Plot symbol	Plant growth (DOY)		Plant growth period (days)	Plant cut and soil sample at (DOY)	Plant cut and soil sample at dayhour	Number of reading
		From	To				
1st	A1	1	29	28	29	10 a.m	2688
2nd	B1	8	36	28	36	10 a.m	2688
3rd	C1	15	43	28	43	10 a.m	2688
4th	D1	22	50	28	50	10 a.m	2688
5th	A2	29	57	28	57	10 a.m	2688
6th	B2	36	64	28	64	10 a.m	2688
7th	C2	43	71	28	71	10 a.m	2688
8th	D2	50	78	28	78	10 a.m	2688
9th	A3	57	85	28	85	10 a.m	2688
10th	B3	64	92	28	92	10 a.m	2688
11th	C3	71	99	28	99	10 a.m	2688
12th	D3	78	106	28	106	10 a.m	2688
13th	A4	85	113	28	113	10 a.m	2688
14th	B4	92	120	28	120	10 a.m	2688
15th	C4	99	127	28	127	10 a.m	2688
16th	D4	106	134	28	134	10 a.m	2688
17th	A5	113	141	28	141	10 a.m	2688
18th	B5	120	148	28	148	10 a.m	2688
19th	C5	127	155	28	155	10 a.m	2688
20th	D5	134	162	28	162	10 a.m	2688
21st	A6	141	169	28	169	10 a.m	2688
22nd	B6	148	176	28	176	10 a.m	2688
23rd	C6	155	183	28	183	10 a.m	2688
24th	D6	162	190	28	190	10 a.m	2688
25th	A7	169	197	28	197	10 a.m	2688
26th	B7	176	204	28	204	10 a.m	2688
27th	C7	183	211	28	211	10 a.m	2688
28th	D7	190	218	28	218	10 a.m	2688
29th	A8	197	225	28	225	10 a.m	2688
30th	B8	204	232	28	232	10 a.m	2688
31st	C8	211	239	28	239	10 a.m	2688
32nd	D8	218	246	28	246	10 a.m	2688
33rd	A9	225	253	28	253	10 a.m	2688
34th	B9	232	260	28	260	10 a.m	2688
35th	C9	239	267	28	267	10 a.m	2688
36th	D9	246	274	28	274	10 a.m	2688
37th	A10	253	281	28	281	10 a.m	2688
38th	B10	260	289	28	288	10 a.m	2688
39th	C10	267	295	28	295	10 a.m	2688
40th	D10	274	302	28	302	10 a.m	2688

RESULTS AND DISCUSSION:

1- Variations of sandy soil temperature through depths:

Data of soil temperature were recorded every fifteen minutes for each selected depth, from the 1 DOY until 300 DOY, and every month with own days, which recorded daily according to Julian calendar that regard the year equal 365 or 366 days (DOY).

The values of soil temperature (Figs.1 & 2) show that the average monthly soil temperature drawdown in the four depths at day night which continued at day light then start to draw up. The three surface depths (0.05, 0.1 and 0.15) behaved in similar way, where the minimum soil temperatures were recorded at the hour of 8th, 8th, 7th, 7th, 6th, 6th, 8th, 8th, 8th and 8th O'clock a.m. for the following months from January to October, respectively. As for those of the depth of 0.3m, the values decrease also, but they started increased from the time of 10th, 10th, 9th, 9th, 9th, 9th, 10th, 10th, 10th and 10th O'clock a.m. at the ten abovementioned months, respectively.

Soil temperature for the three surface depths reached the maximum values at the hour of 3rd, 3rd, 3rd, 3rd, 3rd, 3rd, 4th, 5th, 4th, and 4th O'clock p.m. for the following month from January to October respectively, while those for depth 0.3m, the values reached maximum at the time of 6th, 6th, 7th, 7th, 7th, 7th, 8th, 8th, 8th and 7th O'clock p.m. for the same months, respectively, then they started to decrease. It is worth to mention that soil temperature start to decrease at the night until the seventh to eighth O'clock a.m. after sunrise, while it increased at the day until the third to fifth O'clock p.m. at the surface layers depth for the previous periods. However the temperature values of the studied deepest layer (0.3m) decreased at night until the ninth to tenth O'clock a.m., after sunrise, and increase until the sixth to eighth O'clock p.m. after sunset. **Teasdale and Mohler (1993)** mentioned that organic mulches decreases the maximum but increases the minimum soil temperature.

Soil temperature varies from month to month as a function of incident solar radiation, rainfall, seasonal swings in overlying air temperature, local vegetation cover, type of soil, and depth in the earth. The minimum and maximum soil temperature are listed in Table (3) and depicted in Figs.(3 & 4) which show that during the summer period, the soil temperature was higher in comparison to winter period. Depth average of soil temperature of the months from January to October as depicted in previous mentioned curve figures were ranged between 11-16, 10-17, 12-19, 15-22, 20-27, 23-30, 26-31, 25-29, 24-28, 21-25ºC respectively.

Fig.(1) explained that soil temperature for the four depths (0.05, 0.1, 0.15 and 0.3m) decreased through the month of January and the minimum depression was at February, where it reached 12.26, 12.43, 12.18 and 12.97ºC for the following previous depths, respectively. The values started to increase from this date till the seventh of July where reached 28.79, 27.89, 29.13 and 28.61 for the previous depths. The average values of the minimum were 6, 6.64, 6.07 and 9.33ºC in February and the maximum were 35.58, 34.83, 38.15 and 31.79°C in July for the aforementioned depths (table 3). Generally, the same trend in the soil temperatures was at the four depths. Thus in spring, the soil naturally warms more slowly and to a lesser extent than the air, and by summer, it has become more warm than the overlying air. Likewise in autumn, the soil cools more slowly and to a lesser extent than the air, and by winter it is warmer than the overlying air.

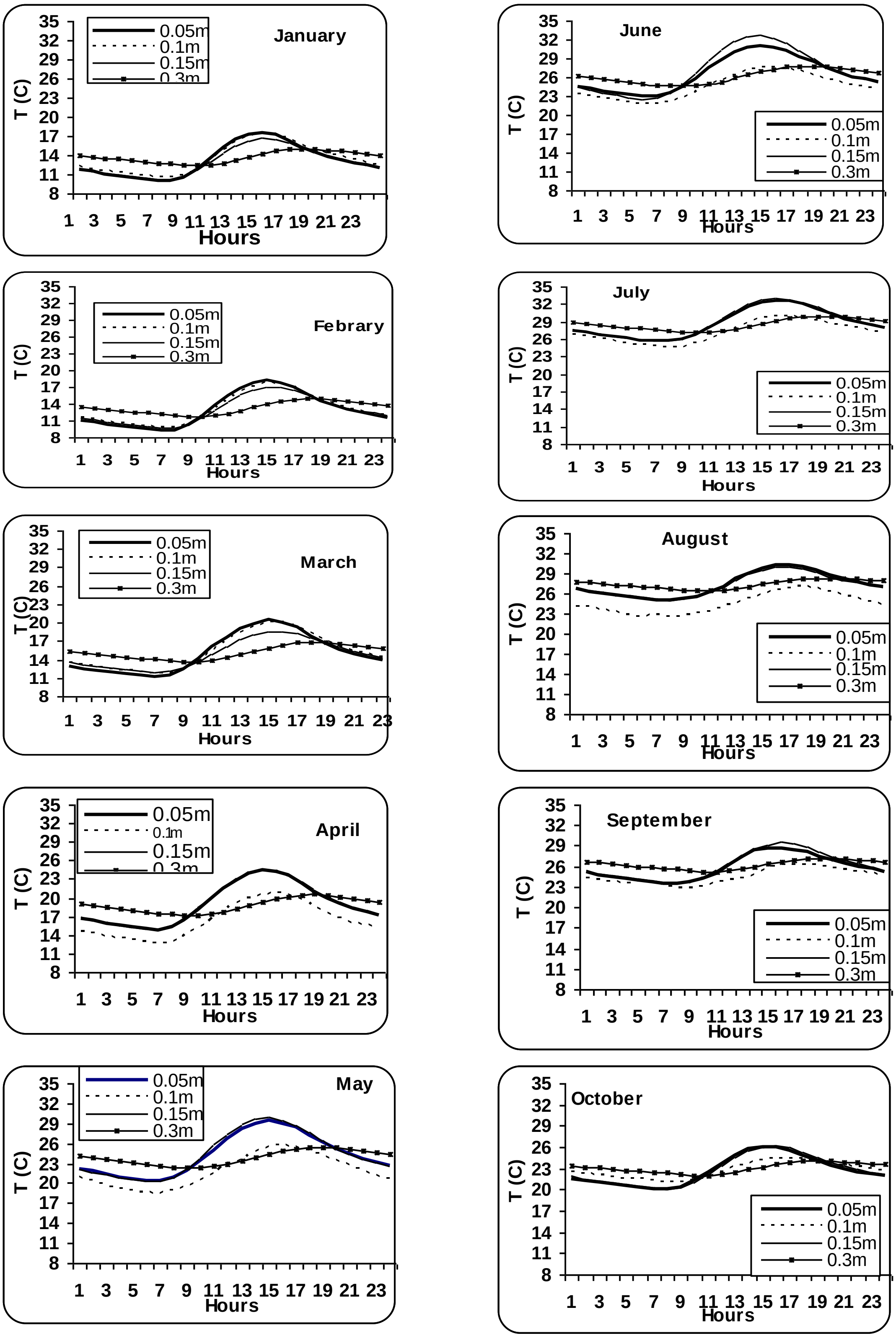

Fig.(1):Every line for every figures represent the depth of daily average of soil temperature from January to October.

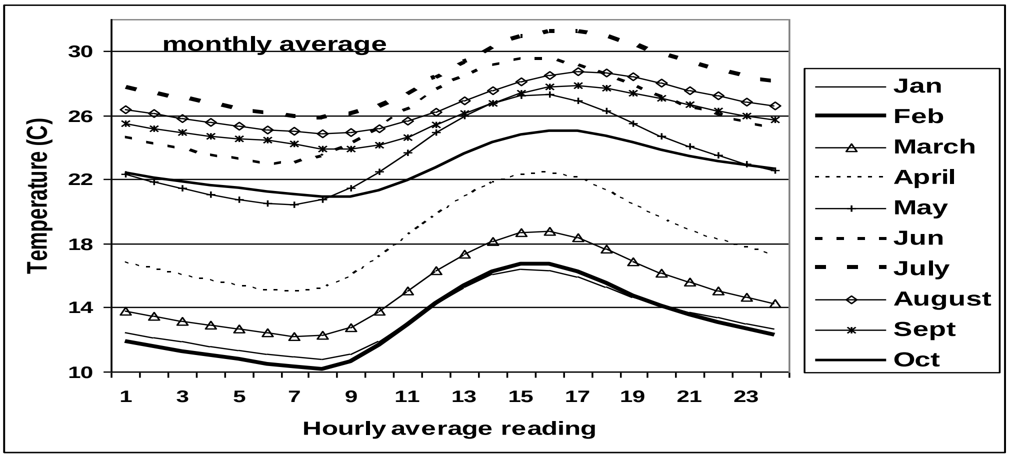

Fig (2): Soil temperature of depth average represented 24 h a day for every monthly average

Table (3): Minimum and maximum average soil temperature (°C) of the four depths of ten months.

Months	Minimum temperature				Maximum temperature			
	0.05m	**0.1m**	**0.15m**	**0.3m**	**0.05m**	**0.1m**	**0.15m**	**0.3m**
January	8.68	9.12	8.60	11.52	19.48	19.00	19.47	15.86
February	6.00	6.64	6.07	9.33	22.35	20.96	21.16	17.64
March	9.40	9.93	10.26	12.21	23.99	22.49	22.56	18.49
April	9.76	6.94	9.65	13.34	31.16	28.77	31.36	25.06
May	15.98	14.35	15.54	18.45	34.30	31.31	34.57	27.78
June	19.68	15.43	19.49	22.24	33.13	33.44	36.90	29.89
July	24.51	20.85	24.68	26.34	35.58	34.83	38.15	31.79
August	23.33	14.10	23.24	24.89	33.70	30.76	33.05	30.02
September	20.00	17.83	20.49	22.50	32.40	29.10	32.74	28.82
October	16.85	18.32	17.06	19.65	28.55	26.86	29.46	26.09
Mean	15.42	13.35	15.51	18.05	29.43	27.75	29.94	25.14

The shadow values are the minimum and maximum data

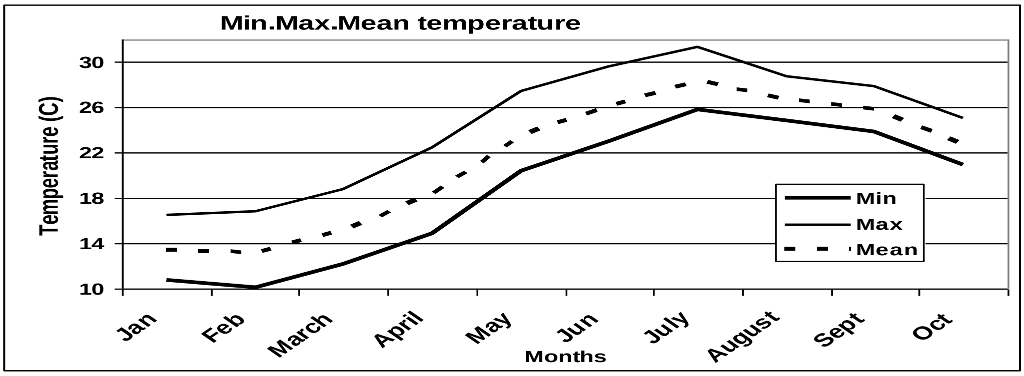

Fig (3): Minimum, maximum and average of soil temperature represent the studied months and depth average.

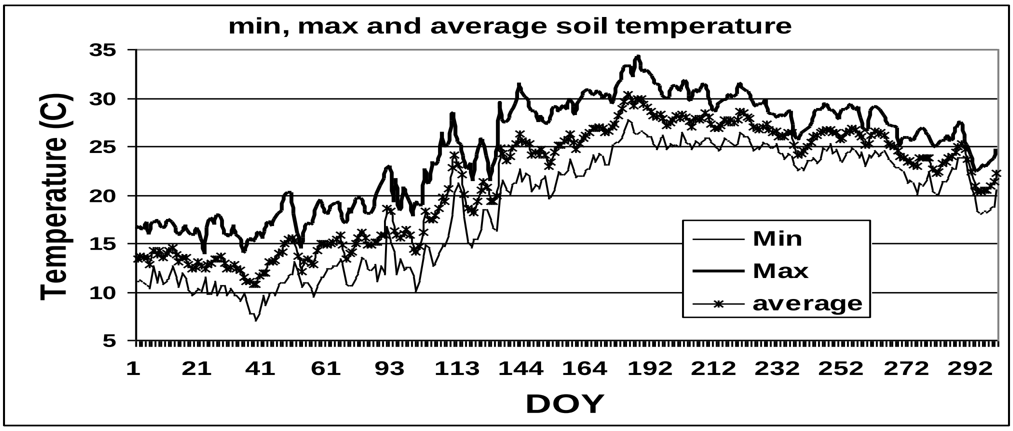

Fig.(4): Minimum, maximum and average of soil temperature represent the studied days (as Julian calendar),(DOY=Day Of Year).

2-Alfalfa dry weight (kg/m^2) and soil temperature (C):

Many environmental factors influence the growth and development of plant root systems. Among these factors are soil strength, soil water status and soil aeration, as well as soil temperature. Plant roots grow in diverse thermal environments and relatively small changes in soil temperature can have a significant impact on the development of the root system depending on the stage of growth of the plant and the duration of the temperature change. Data listed in Tables (4) showed that alfalfa dry weight values range between 1.67 at soil temperature 13.20ºC and 6.70 kg/m^2 at soil temperature 26.20ºC. Thereby, it was a significant correlation between dry weight (Kg/m^2) and average temperature through the period of cut. Fig.(5) shows that dry weight more or less increase with increasing soil temperature, while it was not matched exactly with average soil temperature, this may be due to other factors not interested in this research, also, in Fig.(6) ascending rank of alfalfa cuts was congruent with the previous trend.

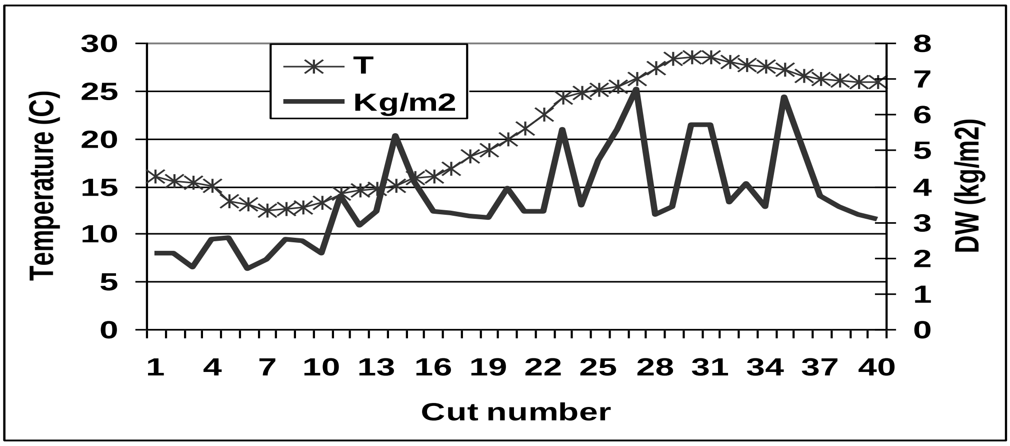

Fig (5): Average soil temperature and dry weight of alfalfa crop through cuts

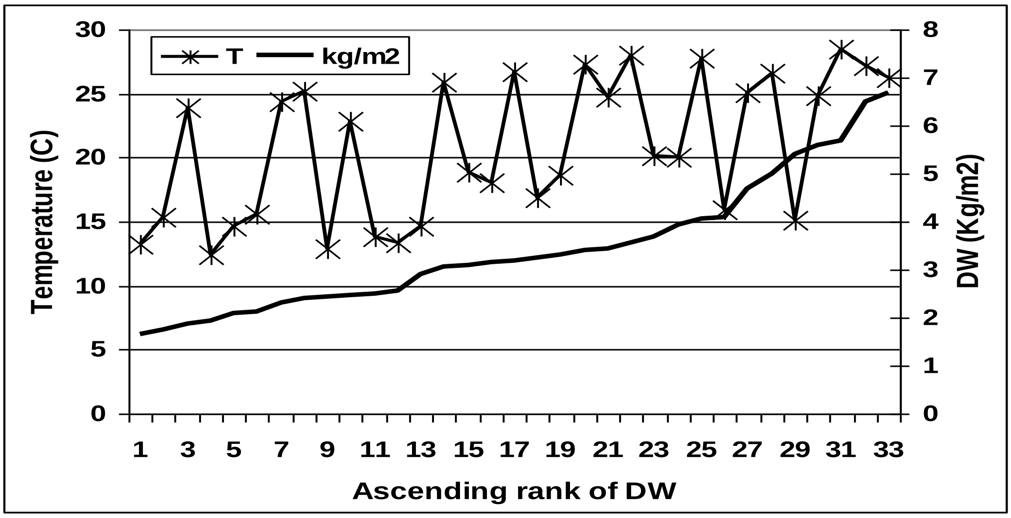

Fig (6): Rank dry weight of alfalfa crop cuts and mean soil temperature, (rank mean damping the refine values).

Table (4): Dry weight of alfalfa (kg/m^2) and average of soil temperature through 28 day every cut.

DOY	Cut No.	T (°C)	Kg/m^2	DOY	Cut No.	T (°C)	Kg/m^2
29	1	13.41	2.55	**169**	21	25.10	4.70
36	2	13.20	1.67	**176**	22	25.44	5.60
43	3	12.46	1.95	**183**	23	26.20	6.70
50	4	12.62	2.50	**190**	24	27.40	3.20
57	5	12.88	2.45	**197**	25	28.39	3.40
64	6	13.34	2.10	**204**	26	28.54	5.70
71	7	14.19	3.70	**211**	27	28.50	5.70
78	8	14.60	2.90	**218**	28	28.05	3.55
85	9	14.84	3.30	**225**	29	27.76	4.05
92	10	15.13	5.40	**232**	30	27.57	3.40
99	11	15.93	4.10	**239**	31	27.19	6.50
106	12	16.08	3.30	**246**	32	26.63	5.00
113	13	16.84	3.25	**253**	33	26.19	3.70
120	14	18.11	3.15	**260**	34	26.04	3.40
127	15	18.86	3.10	**267**	35	25.98	3.20
134	16	20.00	3.95	**274**	36	25.90	3.07
141	17	21.05	3.30	**281**	37	25.17	2.40
148	18	22.60	3.30	**288**	38	24.34	2.30
155	19	24.28	5.60	**295**	39	23.86	1.87
162	20	24.75	3.45	**302**	40	22.87	2.46

The shadow values are the minimum and maximum values of dry weigh

3- Soil temperature (°C) and soil available nutrients contents (ppm):

Evidence is presented to show that both morphological changes and changes in root function such as water and nutrient uptake are influenced by changes in soil temperature. Genetic diversity in the growth of roots in response to temperature was also shown to occur. The values shown in Table (5) revealed that soil available K, Mn and Zn are not related to soil temperature which was not significantly correlated. As for available Fe, it was highly significant and positive correlated with soil temperature. Table (6) showed that soil available Fe ranged from 2.67 and 17.33 ppm. Fig (7 and 8) showed that Fe increased in the summer season, also ascending ranked soil available Fe increased with soil temperature. These results were consistent with those obtained by **Bhowmick, et. al. (2013)**.

Table (5): The correlation coefficient between soil temperature (°C) and alfalfa dry weight (kg/m²), also between soil temperature and available contents of nutrients (ppm).

T (C°)	Kg/m²	Soil available (ppm)			
		K	Fe	Mn	Zn
T(C°)	**				
		Ns			
			**		
				Ns	
					Ns

NS = not significant, *, ** = significant

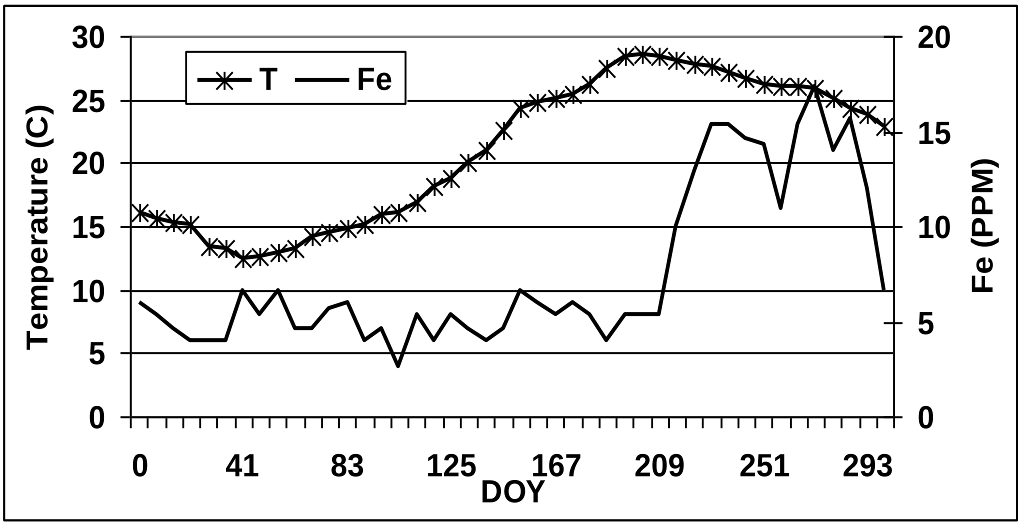

Fig. (7): The average of soil temperature and soil available content of Fe at three depths, (DOY=Day Of Year).

Table (6): Ascending rank of soil available Fe and soil temperature (°C)

Fe (ppm)	Soil temperature (°C) at different depths			
	0.05m	**0.1m**	**0.15m**	**0.3m**
2.67	16.49	14.55	16.54	16.75
4.00	17.76	16.95	17.81	17.98
4.67	17.07	16.23	17.09	17.22
5.33	22.58	21.18	22.84	22.56
5.67	14.52	14.65	14.46	14.76
6.00	20.51	19.35	20.62	20.62
6.67	18.16	17.58	18.25	18.51
10.00	28.45	26.52	28.84	28.40
11.00	26.59	23.68	26.87	27.00
12.00	23.68	23.67	23.92	24.16
13.00	28.27	26.01	28.52	28.25
14.00	25.20	24.37	25.48	25.63
14.33	26.85	23.75	27.01	27.15
14.67	27.30	24.48	27.27	27.45
15.33	27.46	24.94	27.61	27.63
15.67	24.29	23.87	24.50	24.71
17.33	26.08	24.50	26.47	26.54

(Rank means damping the refine values)

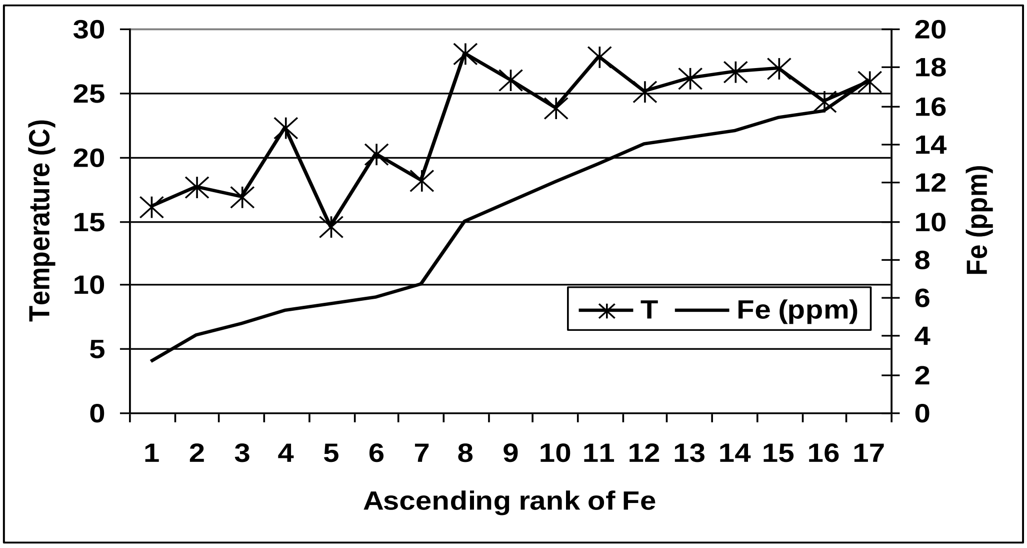

Fig (8): Ascending rank of the average soil available Fe and soil temperature, (Rank means damping the refine values).

4- Soil temperature (°C) and plant nutrients content (ppm)

The concentrations of plant -N, -P and –K (ppm) were negative highly significant correlated with soil temperature (Table 7). Those may be due to dilution for the increase plant growth with soil temperature. That can be sure for the uptake of these nutrients, which P and K (mg/m^2) are positive correlated with soil temperature except N was negatively correlated. **DONG, et. al. (2001)** concluded that a combination of low soil temperature and plant developmental stage influences the ability of apple trees to take up and use N from the soil in the spring. Thus, early fertilizer application in the spring when soil temperatures are low or when the aboveground portion of the tree is not actively growing may be ineffective in promoting N uptake.

Table (7): The relation between soil temperature and nutrients available contents (ppm) and uptake (mg/m^2).

T	Nutrients concentration (ppm)			Nutrients uptake (mg/m^2)		
	N	P	K	N	P	K
12	4.06	0.47	3.48	93.29	10.91	80.28
13	4.38	0.46	3.60	92.11	9.53	75.45
14	4.12	0.45	3.53	135.89	14.73	116.44
15	4.38	0.39	2.98	137.17	12.40	99.55
16	4.38	0.37	3.33	126.68	10.74	98.02
18	4.27	0.43	3.27	133.31	13.13	102.03
20	3.71	0.37	3.41	146.55	14.62	134.83
21	3.58	0.38	3.37	117.98	12.54	111.08
22	3.95	0.40	3.37	112.24	11.25	96.07
23	3.73	0.44	3.17	69.75	8.23	59.25
24	3.75	0.40	3.35	137.18	14.45	123.71
25	3.61	0.37	3.23	133.11	13.49	120.95
26	3.15	0.32	3.15	151.67	14.95	148.46
27	3.11	0.34	3.17	129.51	14.55	136.79
28	3.27	0.36	3.07	148.26	16.10	140.25
	**					
		**				
			*			
T(C°)				**NS**		
					*	
						**

NS = not significant, *, ** = significant

Future:

Soil temperature can be modified by regulating soil moisture, proper soil management practices, good drainage, and application/use of mulching and sufficient addition of organic matter.

The utilization of molecular modifications of existing germplasm to improve root growth under adverse soil temperature conditions was presented for possible future research.

REFERENCES:

Bhowmick, A.C., Salma, U., Siddiquee, T.A., Russel, M. and Bhoumik, N.C. (2013), Effect of Temperature on the Uptake of Na^{+}, K^{+}, Ca^{2+} and Mg^{2+} By the Various Anatomical Parts of the Vegetable Amaranth Gangeticus. IOSR Journal Of Environmental Science, Toxicology And Food Technology (IOSR-JESTFT) E-ISSN: 2319-2402,p- ISSN: 2319-2399. Volume 3, Issue 6 (May. - Jun. 2013), PP 20-31

Bouwmeester, R.J.B.; Vlek, P.L.G. and Stumpe, J.M., (1985), Effect of environmental factors on ammonia volatilization from a urea-fertilized soil. Soil Sci. Soc. Am. J. 49:376-381.

DONG, Sh., CAROLYN F. SCAGEL, CHENG, L., FUCHIGAMI, L.H. and PAUL T. RYGIEWICZ4, P.T. (2001) Soil temperature and plant growth stage influence nitrogen uptake and amino acid concentration of apple during early spring growth Tree Physiology 21, 541 – 547 Heron Publishing — Victoria, Canada.

Emmett, B.C. Beier; M. Estiarte; A. Tietema; H. Kristensen; D. Williams; J. Penuelas; I. Schmidt, and A. Sowerby (2004). The response of soil processes to climate change results from manipulation studies of shrublands across an environmental gradient Ecosystems (N.Y. Print), 7. 625-637, doi : 10. 1007 / s10021 – 004 – 0220 - x.

Engels, C. and Marschner, H. (1992), Root to shoot translocation of macronutrients in relation to shoot demand in maize (Zea mays L.) grown at different root zone temperature. Z. Pflanzen. Borden. 155:121-128 (C.F. Shufu et al. 2000, Soil temperature and plant growth stage influence nitrogen uptake and amino acid concentration of apple during early spring growth. Victoria, Canada, Tree Physiology 21:541-547.

Fenn, L.B. and Kissel, D.E. (1974), Ammonia volatilization from surface application of ammonium compounds on calcareous soils: II. Effects of temperature and rates of ammonium nitrogen application. Soil Sci. Soc. Am. Proc. 38:606-610.

Freed, R.; Eisensmith, S.P.; Goetz, S.; Reicosky, D.; Sail, W.W. and Wokberg, P. (1989), User's Guide to Mstat-C "A software program for the design, Management and Analysis of Agronomic Research Experiments, Michigan State University

Hwang, S. F., Gossen, B. D., Turnbull, G. D., Chang, K. F., Howard, R. J. and Thomas, A. G. (2000a). Effects of temperature, seeding date, and seed

treatments on damping off and root rot of field pea caused by Pythium spp. Can. J. Plant Pathol. 22: 392–399.
Hwang, S. F., Gossen, B. D., Turnbull, G. D., Chang, K. F., Howard, R. J. and Thomas, A. G. (2000b). Effects of temperature, seeding date, fungicidal seed treatment and inoculation with Fusarium avenaceum on seedling survival, root rot severity and yield of lentil. Can. J. Plant Sci. 80: 899–907.
Hillel, D. (2004). Introduction to Environmental Soil Physics. Academic Press, INC.
Horton, R.; Aguirre-Luna, O. and Wierenga, P.J. (1984), Observed and predicted soil temperature distributions under a row crop. Soil Sci. Soc. Am. J. 48:1147-1152.
Hu, Q.S. and Feng, S., (2002). A daily soil temperature dataset and soil temperature climatology of the contiguous United States, submitted to Journal of Applied Meteorology, Sept., 2002.
Jackson, M. (1967). Soil Chemical Analysis. Constable Co. Ltd., London
Kluitenberg, G.J. and Horton, R. (1990), Analytical solution for two-dimensional heat conduction beneath partial surface mulch. Soil Sci. Soc. Am. J. 54:1197-1206.
Kraft, J. M. and Roberts, D. D. (1969). Influence of soil water and temperature on the pea root rot complex caused Pythium ultimum and Fusarium solani f. sp. pisi. Phytopathology 59: 149–152
Mclnnes, K.J. (2002), Soil Heat: 5.1.Temperature, p.1183-1199, In J.H. Dane and G.C.Topp (eds) Methods of soil analysis, Part 4. Physical Methods, SSSA Madison., W.I.
McMichael, B.L. and Burke, J.J. (1998), Soil temperature and root growth. Hort. Science 33: 947-951.
Murphy, J. and Riley,J.P. (1962), A modified single solution method for the determination of phosphate in natural waters. Anal. Chim. Acta. 27:31-36.
Popiel, C.; Wojtkowiak, J. and Biemacka, B. (2001), Measurements of temperature distribution in ground. Experimental Thermal and Fluid Science vol 25 pp 301-309 (C,F.Georgios Florides and soteris Kalogirou, "Measurements of Ground Temperature at Various Depths". Higher Technical Institute, Nicosia, Cyprus, Skalogir@spidernet.com.cy.
Richards, L.A. (1954), Diagnosis and Improvement of Saline and Alkali Soil. U.S. Salinity Lab staff, USA, Agricultural Handbook , No. 60
Rustad, L. E.; J. L. Campbell; G. M. Marion; R. J. Norby; M. J. Mitchell; A.E. Hartley; J. H. C. Cornelissen and J. Gurevitch (2001). A metaanalysis of the response of soil respiration, net nitrogen mineralization and aboveground plant growth to experimental ecosystems warming. Oecologia, 128, 543-562.

Sippell, D. W. and Hall, R. (1982). Effects of pathogen species, inoculum concentration, temperature, and soil moisture on bean root rot and plant growth. Can. J. Plant Pathol. 4: 1–7.

Soltanpour, P.N. (1985), Use of ammonium bicarbonate DTPA soil test to evaluate elemental availability and toxicity. Commun. Soil Sci. Plant Anal. 16 (3):323-338.

Talaat, A.M. and Hoda, M. Said (2008), Studies on the thermal regime of maryout soil. 2. Effect of shading and mulching with bituminous emulsion on total heat retention in the soil profile. Egypt. J. Soil Sci, 48 (3) 279-291.

Teasdale, J.R. and Mohler, C.L. (1993), Light transmittance, soil temperature, and soil moisture under residue of hairy vetch and rye. Agron. J. 85: **673-680.**

Toselli, M.; J.A. Flore; B. Maragoni and A. Masia (1999). Effects of root-zone temperature on nitrogen accumulation by non-bearing apple trees. J. Hort. Sci. Biotech. 74: 118-124.

Vasilieva, G.; N. Mironomva and A. Glyanko (1999). Low above-zero temperature effect in the root zone on nitrate reductase activity and nitrate content in pea organs with stage of growth. J. Plant Nutr. 22: 967-976.

Weih, M. and P.S. Karlsson (1999). The nitrogen economy of mountain birch seedlings implications for winter survival. J. Ecol. 87: 211-219.

الملخص العربى

تغير حرارة التربة فى الأراضى الرملية وعلاقتها بمحصول البرسيم الحجازى

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تـم وضـع ثمانيــة موصــلات حساســة لقيــاس حــرارة التربــة متصــلة بوحــدة تســجيل البيانــات الحراريــة فــى ارض رمليــة بمحطــة بحــوث الأســماعيلية وذلــك فــى مجمــوعتين وبعــد زراعــة الأرض بالبرســيم الحجــازى تــم اختيــار مســاحة تمثــل اربعــة اقســام (أ ، ب ، ج ، د) كــل قســم مساحته واحـد متـر مربـع . وضـعت الحساسـيات الحراريـة لتمثـل الأقسـام الأربعـة علـى اعمـا ق ٠.٠٥، ٠.١، ٠.١٥ و ٠.٣ متـرمن سـطح الأرض، حيـث وضـعت مجموعـة مـن الحساسـات بـين القسـمين (أ و ب) ووضـعت المجموعـة الثانيـة بـين القسـمين (جـ و د) وعلـى نفـس الأعمـاق السـالفة، وتـم تسـجيل حـرارة التربـة كـل ١٥ دقيقـة ، وفـى نهايـة التجربـة تـم حسـاب المتوسـط للمجمـوعتين لكـل عمـق، وتـم حسـاب درجـة حـرارة التربـة يـومى كمتوسـط شـهرى ابتـداء مـن ينـاير حتـى اكتـوبر، وقـد اخـذت حشـات البرسـيم بالتتـابع مـن القسـم (أ) وبعـد اسـبوع اخـذت مـن القسـم (ب) وبعـد اسـبوع اخـذت مـن القسـم (ج) وبعـد اسـبوع اخـذت مـن القسـم (د) ثـم تكـرار ذلـك، علـى أن يـتم اخـذ حشـة كـل ٢٨ يـوم وينسـحب ذلـك علـى اول حشـة ايضـا، وعلـى ذلـك يكـون عـدد الحشات من أول يناير حتى اخر اكتوبر ٤٠ حشة.

وقد أوضحت النتائج مايلى:

أن قـيم درجـات حـرارة التربـة تتنـاقص مـن منتصـف الليـل حتـى السـاعة السـابعة الـى الثامنـة بعـد شـروق الشـمس، ثـم تبـدأ فـى الأرتفـاع مـن السـاعة الثالثـة الـى الخامسـة وذلـك بالنسـبة للأعمـاق الثلاثة السطحية (٠.٠٥، ٠.١، ٠.١٥متر).

كمـا اوضـحت النتـائج ان حـرارة التربـة عنـد العمـق ٠.٣ متـر تتنـاقص لـيلا حتـى السـاعة التاسـعة الـى العاشـرة بعـد شـروق الشـمس، ثـم تبـدأ فـى الأرتفـاع مـن السـاعة السادسـة الـى الثامنـة بعـد الظهر.

كمـا ظهـر ان اقـل درجـة حـرارة تربـة تـم تسـجيلها كانـت ٦ ، ٦.٦٤ ، ٦.٠٧ و ٩.٣٣ درجـة مئويـة وذلـك فـى شـهر فبرايـر وان اعلـى درجـة حـرارة تربـة تـم تسـجيلها كانـت ٣٥.٥٨ ، ٣٤.٨٣ ، ٣٨.١٥ و ٣١.٧٩ درجة مئوية فى شهر يوليو للأعماق الأربعة سالفة الذكر.

يوجـد ارتبـاط معنـوى موجـب بـين الـوزن الجـاف للبرسـم الحجـازى وبـين حـرارة التربـة حيـث يـزداد الـوزن الجـاف مـع زيـادة حـرارة التربـة . وان اقـل وزن جـاف (١.٦٧ كجم/متـر مربـع) كـان عنـد الحشـة الثانيـة عنـد درجـة حـرارة التربـة (١٣.٢ درجـة مئويـة)، بينمـا كانـت أعلـى قيمـة للـوزن الجـاف (٦.٧٠ كجم/متـر مربـع) كانـت عنـد الحشـة الــ ٢٣ وذلـك عنـد درجـة حـرارة تربـة (٢٦.٢٠ درجة مئوية).

لا يوجـد ارتبــاط معنــوى بــين عناصــر البوتاســيوم المنجنيــز والزنــك الميســر فــى التربــة وبــين حـرارة التربـة ولكـن يوجد ارتبـاط معنـوي موجـب بـين الحديـد الميسـر وبـين حـرارة التربـة حيـث يـزداد بزيـادة حـرارة التربـة، أيضـا يوجـد ارتبـاط معنـوى سـالب بـين تركيـز كـل مـن عناصـر النتـروجين والفوسـفور والبوتاسـيوم فـى النبـات وبـين حـرارة التربـة وذلـك راجـع للتخفيـف مـع زيـادة نمـو النبـات، حيـث يوجـد ارتبـاط معنـوى موجـب بـين المحتـوى الممـتص مـن كـل مـن الفوسفور والبوتاسيوم ودرجة حرارة التربة.